

A/Reissue

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Inventor(s): Takeshi YUKITAKE, et al.

APPLICATION BRANCH

Serial No.: Reissue Application
of U.S. Patent No. 5,745,182
(issued: April 28, 1998)

Filed: April 27, 2000

For: METHOD FOR DETERMINING MOTION COMPENSATION

REISSUE APPLICATION TRANSMITTAL

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Attached is an application for reissue of U.S. Patent No. 5,745,182 to Takeshi YUKITAKE, et al., issued on April 28, 1998. The following documents form a part of this submission:

1. Two pages title sheet with Abstract.
2. Twelve (12) pages specification.
3. Thirty-one (31) claims, including amended claim 1, unamended claims 2 and 3 and new claims 4-31.
4. Six (6) sheets of informal drawings (Figs. 1-8).
5. Statement Under 37 C.F.R. 3.73(b).
6. Offer to Surrender Original Patent.
7. Assent of Assignee to Reissue.
8. Information Disclosure Statement.
9. Confirmation Claim For Priority.

10. Check No. 13243 for \$2,292.00.

CALCULATION OF FILING FEES

Basic filing fee	\$ 690.00
No. independent claim in excess of number in patent - 18 x \$78.00	1,404.00
No. total claims in excess of 20 or number of total claims in patent - 11 x \$18.00	<u>198.00</u>
TOTAL	\$2,292.00

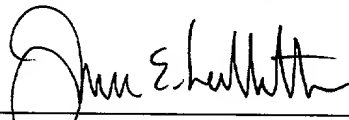
Our check No. 13243 for \$2,292.00 is attached. If any additional fees are needed, please debit our Deposit Account No. 19-4375 to effect immediate filing of this application.

The Commissioner is hereby authorized to charge payment of the following fees associated with this communication and/or fees required during the pendency of this application (or credit overpayments) to DEPOSIT ACCOUNT No. 19-4375. A duplicate copy of this letter is attached.

-/- Any additional filing fees or fees for presentation of extra claims under 37 CFR §1.16.

-/- Any patent application processing fees under 37 CFR §1.17.

Respectfully submitted,



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CHANGE OF CORRESPONDENCE ADDRESS

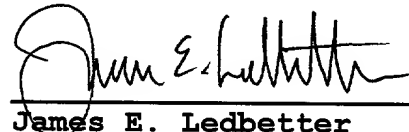
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METHOD FOR DETERMINING MOTION COMPENSATION

This is a division of application Ser. No. 07/970,046 filed Nov. 2, 1992, now U.S. Pat. No. 5,369,449.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method for determining motion compensation of a moving image to be utilized in an apparatus which requires a prediction of a moving image such as an image transmission apparatus and an image apparatus.

2. Description of the Prior Art

With the progress of semiconductor technologies, methods for determining motion compensation to be utilized for a transmission of an image and a compression of an image have been widely used in many fields in recent years. Among such conventional methods for compensating for motion of a moving image, there is one method for compensating for motion of a moving image based on one piece of a reference image.

FIG. 6 is a diagram for showing the concept of the conventional method for compensating for motion of an image. Referring to FIG. 6, a moving image signal is a set of images which are sampled with an equal time interval t_0 on the time axis. For example, an NTSC signal has images sampled at every $1/60$ second for each field and a PAL signal has images sampled at every $1/50$ second for each field. When a certain object of which images are to be picked up is moving, for example, the spatial position of an object A in an M-th image is deviated from the spatial position of an object A' in an (M-1)-th image by a portion of a move of the object during a period of t_0 . Now, consider a case for predicting the M-th image from the (M-1)-th image. In order to make a determination of the M-th image with a high level of precision by compensating for motion of the object from an input image to a reference image during a time difference of t_0 , the M-th image is divided into blocks including at least one pixel, and a move of each block from the (M-1)-th image to the M-th image is detected so that a pixel value of the image at a position deviated by the portion of this move is set as a determined value. This will be explained with reference to FIG. 6. To obtain a determined value of a pixel X of the M-th image, a pixel X' at the same spatial position as the spatial position of the pixel X in the (M-1)-th image is deviated by a detected move MV of a block unit including the pixel X', so that a pixel X" is obtained. This pixel X" is then used as a determined value of the pixel X. In FIG. 6 the block is assumed to have a size of 3×3 .

When a signal is an interlace signal, there are many alternative cases considered for predicting compensation for motion of an image. For example, either a frame or a field is used for the image, and a frame is used for a reference image and a field is used for an input image, etc. The basic principle is as explained with reference to FIG. 6 above. As one of the examples of the above method for predicting motion compensation, there is Recommendation 723, "Transmission of component-coded digital television signals for contribution-quality at the third hierarchical level of CCITT Recommendation G.702" which was standardized by the CCITT (Commission Mixte CCIR/CCITT pour les Transmissions Televisuelles et Sonores 3). In this recommendation, a determination of motion compensation between frames and a determination of motion compensa-

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The above-described conventional method for determining motion compensation, however, has problems that it is not possible to accurately determine motion compensation and that, even if it is possible to correctly determination of motion compensation, the image density of an image to be referred to becomes the image density of a reference image, which makes it impossible to make prediction at a higher level of precision.

For example, in the case of determining motion compensation by using an interlace signal as a frame and generating a block from this frame, frames are combined together to compensate motion of an image by disregarding a difference in sampling positions, due to a time difference, between two fields within a frame. Accordingly, when correct sampling positions of the fields are considered, there is such a case that motion compensated in the first field and motion compensated in the second field do not coincide with each other. An example of this case is shown in FIGS. 7A to 7C. Referring to FIGS. 7A to 7C, an input signal is an interlace signal (FIG. 7A). Interlace signals are combined together in a frame to determine motion compensation. When a vertical component of a motion detected now is 1, the first field of the M-th frame is predicted from the second field of the (M-1)-th frame and the second field of the M-th frame is predicted from the first field of the (M-1)-th frame, as shown in FIG. 7B. Moves in the correct field positions is shown in FIG. 7C. As is clear from FIG. 7C, the motion for effecting compensation in the first field of the M-th frame do not coincide with the moves for effecting compensation in the second field of the M-th frame. As explained above, when motion compensation of an image is made by handling an interlace image as a frame, the motion for effecting compensation are different between the first field and the second field. In a vector in which this phenomenon occurs, there is a problem that the precision of the level of prediction is deteriorated.

Next, consider a case of determining motion compensation of an image as an image of a correct position without disregarding a time difference of sampling between images as described above. As examples of this case, there is a case where motion compensation is determined for an interlace signal by generating a block from a field, and a case where motion compensation is determined for a noninterlace signal. In the above cases, motion compensation is predicted by using an image at a position of a correct time. Therefore, there arises no such problem which occurs in the case of determined motion compensation by generating a block from a frame of the interlace signal as described above. However, in this case, motion compensation is determined from one piece of reference image and the pixel density of an image to be referred to becomes the pixel density of the reference image, so that there is a limit to carrying out a determination of motion compensation at a higher level of precision. FIG. 8 shows a case of determined move compensation by generating a block from a field for an input of an interlace signal. In this case, determination of motion compensation is carried out by using a field image as a reference image. Therefore, when a motion vector is 0 there is no sampling point at a position necessary for making a determination on the reference image and, accordingly, a

SUMMARY OF THE INVENTION

In order to achieve the above-described object of the present invention, the method of the present invention determines motion compensation of an input image based on a motion vector of a reference image from an original position of the reference image to a position of the reference image sampled at a first set time, and the method includes calculating a motion vector of an input image by calculating a motion at a second set time of a block unit which is a part of the input image and also consists of a plurality of pixels, and calculating a motion vector of the reference image by calculating a move at the first set time of a block unit which is a part of the reference image and also consists of a plurality of pixels, to thereby calculate motion compensation of the input image at a desired set time both from the motion vector of the input image and from the motion vector of the reference image.

Therefore, according to the present invention, a time position of a reference image is compensated by using a certain motion vector depending on the need so that a plurality of pieces of reference images sampled at different times according to the motion of a block unit, including at least one pixel, which is detected at a certain time interval, become images of the input image at the above time intervals from the position of the input image. Thus, it is possible to obtain a plurality of pieces of images at positions of the above-described time intervals from the position of the input image. By combining these images together, it is possible to

obtain a reference image of high pixel density. Based on this reference image of high pixel density, a pixel value at a position compensated by the detected motion portion is calculated and this is used as a determined value. Accordingly, it is possible to determine motion compensation at a very high level of precision.

Further, according to the present invention, a vector for carrying out compensation of a time position of the reference image can be calculated from motion of the image detected at a certain time interval, so that it is not necessary to detect again the motion vector for correcting the time, and motion compensation at a high level of precision can be ensured.

Further, by using an interlace signal as an input signal and using two fields in a certain frame for a reference image, it becomes possible to suitably apply the above method for determining motion compensation to a frame image, thus ensuring a determination at a high precision level of motion compensation based on a frame.

Further, since the same value is used for a block of each input image, of which whole or part of spatial position of each block is superposed, among blocks of a plurality of pieces of input images, as motion detected at a certain time interval in a block unit including at least one pixel, it is not necessary to carry out motion detection a plurality of times for many blocks of the plurality of input images, thus ensuring a determination of motion compensation at a high level of precision.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram for explaining the first embodiment of the present invention;

FIGS. 2A and 2B are diagrams for explaining the second embodiment of the present invention;

FIG. 3 is a diagram for explaining a block for determining motion compensation using a frame as a base;

FIGS. 4A and 4B are diagrams for explaining the third embodiment of the present invention;

FIG. 5 is a diagram for explaining the fourth embodiment of the present invention;

FIG. 6 is a conceptional diagram for showing the conventional method for determining motion compensation;

FIG. 7A to FIG. 7C are diagrams for explaining problems of the conventional method for determining motion compensation between frames; and

FIG. 8 is a diagram for explaining the conventional method for determining motion compensation between fields.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a diagram for explaining a first embodiment of the present invention. FIG. 1 assumes the determination of motion compensation based on an interlace signal as an input signal so that a block is generated from an image within a field and a field image is used as a base. In this case, the input image is in the M-th field and a reference image is in both the (M-1)-th field and the (M-2)-th field. Now, assume that a motion vector (MV) for predicting move compensation of a certain block is to be detected in a two-field instance, that is, between the M-th field and the (M-2)-th field. To simplify the explanation, of the detected moves, only motion in the vertical direction will be considered, and a pixel value is expressed as $a(x, y)$. In this

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case, x represents a field number and y represents a line number. Line numbers are placed in the order of 1, 2, . . . , starting from the bottom in a line interval of the frame. A position of each pixel in a vertical direction is expressed always in the unit of a frame line.

Now, consider a case for obtaining a determined value of $(M, 1)$. When a vertical component of a detected MV is 1, a determined value of motion compensation of a $(M, 1)$ becomes a pixel value at a position of $(M-2, 2)$. Next, a time position is corrected so that the position of the reference image in the $(M-1)$ -th field becomes an image at the position of the $(M-2)$ -th field. A vector for correcting this time position is set as MV adj (adjustment vector). In calculating the MV adj from the MV, the following relationship can be easily drawn when it is assumed, for example, that motion from the $(M-2)$ -th field to the M -th field is constant:

$$MV\ adj = -MV/2$$

Therefore, when the vertical component of the MV is 1, the vertical component of the MV adj becomes -0.5. When this is applied to the positional correction for correcting the positions of the $(M-1)$ -th field to the positions of the $(M-2)$ -th field, a $(M-1, 2)$ in the $(M-1)$ -th field is corrected to the position of $(M-2, 2.5)$ in the $(M-2)$ -th field, as shown in FIG. 1. After the above operation, the position of $(M-2, 2)$ which is the determined value of motion compensation of the $(M, 1)$ is obtained from pixel values of the $(M-2)$ -th field and the $(M-1)$ -th field which is the result of a time positional correction. In this case, when a necessary pixel value is to be obtained by a weighted average, which is inversely proportional to a distance, from near-by pixel values, for example, the pixel value at the position of the $(M-2, 2)$, that is the determined value of motion compensation of the $(M, 1)$, is obtained by the following expression:

$$a(M-2, 1)/3 + 2 \cdot a(M-1, 2)/3$$

Although the above explains a determination of motion compensation taking account of only vertical components, a similar operation is also applied to the case for determining motion compensation for an image having both vertical and horizontal components.

As described above, according to the first embodiment of the present invention, a time position of a reference image is corrected by using a motion vector as required so that a plurality of pieces of reference images sampled at different times become an image at a time which is positioned within a certain time interval from the position of the input image, according to detected motion at the above time interval of a block unit including at least one pixel. Therefore, it is possible to obtain a plurality of pieces of images at positions which are separated from the input image by the above time intervals. A reference image with high pixel density is obtained by combining these pieces of images, and a pixel value at a position which compensates the detected motion is calculated by using the reference image of high pixel density, and the calculated pixel value is used as a determined value. As a result, there is an effect that it is possible to carry out a determination of motion compensation of an image at a very high precision level.

The assumptions used in the above description of the first embodiment are flexible and the following alternative assumptions can also be accepted. Instead of assuming two images for a reference image, any plurality of number of

In FIGS. 2A and 2B, a determination of a pixel within the M-th field is carried out by using images in the (M-1)-th field and the (M-2)-th field, in exactly the same operation as that of the first embodiment of the present invention. For example, when the vertical component of the MV(M) is 1.5, the determined value of $a(M, 1)$ becomes the pixel value at the position of (M-2, 2.5) according to the operation which is the same as that of the first embodiment, and this value is obtained by the following expression:

Similarly, in the same manner as that of the determination of a pixel within the M-th field, a pixel within the (M+1)-th

field is determined from the two fields of the reference frame, that is, the (M-1)-th and (M-2)-th fields. The method of determination in this case is the same as the method for determining a pixel within the M-th field, except that the (M-2)-th field needs to be corrected to the position of the (M-1)-th field. A vector for correcting this time position is set as MV adj (M+1). In calculating the MV adj (M+1) from the MV(M+1), when the motion from the (M-2)-th field to the (M+1)-th field, for example, are constant, the following relationship can be obtained easily:

$$MV\ adj\ (M+1)=MV(M+1)/2$$

Therefore when the vertical component of the MV(M+1) is 1, the vertical component of the MV adj (M+1) becomes 0.5. As shown in FIGS. 2A and 2B, when the (M-2)-th field is positionally corrected to the position of the (M-1)-th field, the a(M-2, 3) is positionally corrected to the position of the (M-1, 2.5). After the above operation, the position of the (M-1, 3) which is a determined value of the a(M+1, 2) is obtained from the pixel value of the (M-1)-th field and the pixel value of the (M-2)-th field of which time position has been corrected. When a necessary pixel value is to be obtained by a weighted average, inversely proportional to a distance, from near-by pixel values, for example, a determined value at the position of the (M-1, 3), that is, a determined value of motion compensation of the a(M+1, 2), is obtained by the following expression:

$$a(M-1,4)/3+2*a(M-2,3)/3$$

Although the above explains the determination of motion compensation of an image for only the vertical component, a similar operation is also applied to the case for determining motion compensation of an image having both vertical and horizontal components.

As described above, according to the second embodiment of the present invention, the above-described determination of motion compensation can be applied to a frame image, by using an interlace signal as an input signal and by setting a reference image in two fields of a certain frame. As a result, there is an effect that it is possible to determine motion compensation of an image at a high level of precision by using a frame as a base.

The above-described second embodiment also has a flexibility in the assumptions used, in the same manner as that of the first embodiment. For example, the number of reference frames, the positions of the reference frames, the assumptions for obtaining the MV adj (M) or MV adj (M+1) from either the MV(M) or the MV(M+1), the calculation method for obtaining a pixel value at a necessary position, and either interpolation or extrapolation, can also be selected freely. Further, although it is assumed in the present embodiment that a move vector for determining motion compensation can be obtained within the input image and reference frame and between fields of the same phase as that of the input image, it is also possible to obtain the motion vector between fields of opposite phases, in the same manner of operation, with the similar effect. Further, when a position correction vector is obtained independent of a detection motion vector, in the same manner as that of the first embodiment, there is an effect that it is possible to determine motion compensation at a higher level of precision.

Next, as a third embodiment of the present invention, another method for determining motion compensation for an interlace input signal based on a frame unit will be

FIG. 5 is a diagram for explaining a fourth embodiment of the present invention. The fourth embodiment takes the same assumptions as those of the first embodiment, and an interlace signal is used as an input signal, an input image is in the M -th field and a reference image is in both the $(M-1)$ -th field and the $(M-2)$ -th field. Assume in FIG. 5 that

Now consider the case of obtaining a determined value of $a(M, 1)$. When it is assumed that the vertical component of the detected MV is 3, the determined value of move compensation of the $a(M, 1)$ becomes the pixel value at the position of $(M-2, 4)$. First, this pixel value is obtained from the pixel value within the $(M-2)$ -th field. When the pixel value is to be obtained based on a weighted average, inversely proportional to a distance, from near-by pixel values, for example, the pixel value at the position of the $(M-2, 4)$ is obtained by the following expression:

Next, based on the above MV, motion of the input image from the (M-1)-th field to the M-th field is calculated. The time difference between the M-th field and the (M-1)-th field is $\frac{1}{2}$ of the time difference between the M-th field and the (M-2)-th field. Accordingly, this motion vector can be considered to be MV/2. Since the vertical component of the MV is now 3, the vertical component of MV/2 becomes 1.5. Accordingly, when a determined value of motion compensation of the $a(M, 1)$ is obtained from the image in the (M-1)-th field, this becomes the pixel value at the position of (M-1, 2.5). This pixel value is obtained from a pixel value within the (M-1)-th field. When the pixel value is to be obtained by a weighted average, inversely proportional to a distance, from near-by pixel values, for example, the pixel value at the position of (M-1, 2.5) can be obtained by the following expression:

Based on the two determined values obtained above, a mean of the two determined values is obtained and the result is used as the determined value of the $a(M, 1)$.

Although the above explains the case for determining motion compensation of an image for only the vertical component, a similar operation is also carried out for the case of determining motion compensation of an image having both vertical and horizontal components.

As described above, according to the fourth embodiment of the present invention, motion of an input image from a plurality of pieces of reference images sampled at different times according to detected motion at certain time intervals of a block unit including at least one pixel is calculated based on the above detected motion, and a pixel value at a position which has been compensated by the calculated motion portion for each reference image is calculated, so that it is possible to obtain a plurality of determined values of motion compensation from the plurality of pieces of reference images. Since a determined value of the input image is calculated from the plurality of determined values, noise can be eliminated if noise is included in the determined values, thus ensuring a determination at a high precision level, of motion compensation.

In the manner similar to the case of the first embodiment, it is also possible in the fourth embodiment to freely select the number of pieces of reference images, the positions of the reference images, the calculation method for obtaining a

pixel value at a necessary position within each reference image, and either interpolation or extrapolation. For calculating determined values from a plurality of pixel values obtained from the respective reference images, there are other alternative methods than a simple averaging method such as a weighted average method and a method for calculating by using a coefficient of a low-pass filter. Although description has been made of the case for determining motion compensation based on a field of an interlace signed in the present embodiment, it is needless to mention that the effect of the determination does not change if a frame is used as a base or a noninterlace image is used as a base as shown in the second and third embodiments respectively.

According to the present invention, as is clear from the above-described embodiments, a time position of a reference image is corrected by using a motion vector as required so that a plurality of pieces of reference images sampled at different times according to detected motion at certain time intervals of a block unit including at least one pixel become images at times separated from the input image by the above time intervals, so that it is possible to obtain a plurality of pieces of images at positions separated by the above time intervals from the input image. By combining the plurality of pieces of images together, a reference image of high pixel density can be obtained and a pixel value at a position which has been compensated by the detected motion is calculated by using the reference image of high pixel density, so that the calculated pixel value is used as a determined value. Thus, there is an effect that it is possible to determine motion compensation of an image at a very high level of precision.

Further, according to the present invention, a vector for correcting a time position of the above reference image can be calculated based on motion detected at a certain time interval, which does not require a detection again of a motion vector for correcting the time position, so that this has an effect that motion compensation at a high precision level can be ensured. Further, since an interlace signal can be used as an input signal and a reference image can be in two fields of a certain frame, the above determination of motion compensation can be applied to a frame image, thus ensuring a determination, at a high precision level, of motion compensation based on a frame.

Further, since the same value can be used for a block of each input image among blocks of a plurality of pieces of input images, each block having its whole or part of spatial position superposed with that of the other blocks, as a move detected at a certain time interval of a block unit including at least one pixel, it is not necessary to carry out a plurality of detections of moves of many block in a plurality of input images so that there is an effect that a determination of motion compensation at a high precision level can be ensured.

We claim:

1. A method of determining motion compensation for an input image from motion vectors between the input image and a plurality of reference images, said method comprising the steps of:

- (a) calculating a motion vector MV1 between the input image and one reference image of said plurality of reference images [from a motion of at least one block unit] at a second set time interval T_2 between the input image and said one reference image [said at least one block unit being a part of said input image and comprising a plurality of pixels];
- (b) providing a motion vector MV2 between at least two reference images of the plurality of reference images at

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(c) calculating the motion compensation of the input image from both of (i) the motion vector MV1 between the input image and said one reference image and (ii) the motion vector MV2 between the at least two reference images of the plurality of reference images.

(a) detecting a motion vector MV1 between the input image and one reference image R1 of said plurality of reference images at a second set time interval T_2 ;

(c) obtaining a motion vector MV2 between the input image and the another reference image R2 at a third set time interval T_3 from a sum of the motion vector MV1 and the motion vector MV3, and calculating respective pixels corresponding to the motion vector MV1 and the motion vector MV2 from pixels of the reference image R1 and the reference image R2 corresponding to the motion vector MV1 and the motion vector MV2 or from pixels positioned peripherally of the pixels of the reference image R1 and the reference image R2; and

(d) calculating motion-compensated pixel values from the calculated pixels of the reference images.

3. A method of obtaining a motion-compensated image from a motion vector between the motion-compensated image and a plurality of reference images, said method comprising the steps of:

- (a) obtaining a motion vector MV1 between the motion-compensated image and one reference image R1 of said plurality of reference images at a second set time interval T_2 ;
- (b) providing a motion vector MV3 between the reference image R1 and another reference image R2 of said plurality of reference images at a first set time interval T_1 , which is parallel to the motion vector MV1 and different in magnitude from the motion vector MV1 by a value determined by $MV1 \cdot T_1 / T_2$;
- (c) obtaining a motion vector MV2 between the motion-compensated image and said another reference image R2 at a third set time interval T_3 from a sum of the motion vector MV1 and the motion vector MV3, and calculating respective pixels corresponding to the motion vector MV1 and the motion vector MV2 from pixels of the reference image R1 and the reference image R2 corresponding to the motion vector MV1 and the motion vector MV2 or from pixels positioned peripherally of the pixels of the reference image R1 and the reference image R2; and
- (d) calculating motion-compensated pixel values from the calculated pixels of the reference images to obtain the motion-compensated image.

* * * * *

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4. A method in accordance with claim 1, wherein said motion vector MV1 between the input image and said one reference image of said plurality of reference images is calculated from a motion of at least one block unit at said second set time interval, said at least one block unit being a part of said input image and comprising a plurality of pixels.

5. A method in accordance with claim 2, wherein said motion vector MV1 between the input image and said one reference image of said plurality of reference images is calculated from a motion of at least one block unit at said second set time interval, said at least one block unit being a part of said input image and comprising a plurality of pixels.

6. A method in accordance with claim 3, wherein said motion vector MV1 between the motion-compensated image and said one reference image R1 of said plurality of reference images is calculated from a motion of at least one block unit at said second set time interval, said at least one block unit being a part of said input image and comprising a plurality of pixels.

7. A method in accordance with claim 2 or claim 3, wherein step (c) comprises obtaining said motion vector MV2 from a mean of said motion vector MV1 and said motion vector MV3, and said pixels positioned peripherally are valued in accordance with an average weighting inversely proportional to distance from pixels of the reference image R1 and the reference image R2.

8. A method of determining motion compensation for an input image, said method comprising the steps of:

(a) providing a first motion vector MV1 between the input image and a reference image part r1 of one reference image R1 having a plurality of reference image parts;

(b) calculating a second motion vector MV2 between the input image and a reference image part r2 of another reference image R2 having a plurality of reference image parts, from said first motion vector MV1;

(c) calculating pixel values of said reference image parts r1 and r2 from peripheral pixels at positions corresponding to said first and second motion vectors MV1 and MV2, wherein said reference images R1 and R2 are such that a motion

vector MV3 between said reference image parts r1 and r2 has a mathematical relationship with said first and second motion vectors MV1 and MV2 in which said motion vector MV3 is parallel to and different in value from each of said first and second motion vectors MV1 and MV2; and

(d) calculating said motion compensation for said input image from said pixel values calculated in step (c).

9. A method of determining motion compensation for an input image, said method comprising the steps of:

(a) providing a first motion vector MV1 between the input image and a reference image part r1 of one reference image R1 having a plurality of reference image parts;

(b) calculating a second motion vector MV2 between the input image and a reference image part r2 of another reference image R2 having a plurality of reference image parts, from said first motion vector MV1;

(c) calculating pixel values of said reference image parts r1 and r2 from peripheral pixels at positions corresponding to said first and second motion vectors MV1 and MV2, wherein said reference images R1 and R2 are previous to said input image in a time sequence; and

(d) calculating said motion compensation for said input image from said pixel values calculated in step (c).

10. A method for determining a motion-compensated image, said method comprising the steps of:

(a) providing a first motion vector MV1 between the motion-compensated image and a reference image part r1 of one reference image R1 having a plurality of parts;

(b) calculating a second motion vector MV2 between the motion-compensated image and a reference image part r2 of another reference image R2 having a plurality of reference image parts, from said first motion vector MV1;

(c) calculating pixel values of said reference image parts r1 and r2 from peripheral pixels at positions corresponding to said first and second motion vectors MV1 and MV2, wherein said reference images R1 and R2 are such that a motion vector MV3 between said reference image parts r1 and r2 has a mathematical relationship with said first and second motion vectors MV1 and MV2 in which said motion vector MV3 is parallel to and different in

value from each of said first and second motion vectors MV1 and MV2; and

(d) calculating motion-compensated pixel values from said pixel values calculated in step (c) to determine said motion-compensated image.

11. A method for determining a motion-compensated image, said method comprising the steps of:

(a) providing a first motion vector MV1 between the motion-compensated image and a reference image part r1 of one reference image R1 having a plurality of parts;

(b) calculating a second motion vector MV2 between the motion-compensated image and a reference image part r2 of another reference image R2 having a plurality of reference image parts, from said first motion vector MV1;

(c) calculating pixel values of said reference image parts r1 and r2 from peripheral pixels at positions corresponding to said first and second motion vectors MV1 and MV2, wherein said reference images R1 and R2 are previous to said motion-compensated image in a time sequence; and

(d) calculating motion-compensated pixel values from said pixel values calculated in step (c) to determine said motion-compensated image.

12. A method of obtaining a motion-compensated image, said method comprising the steps of:

(a) obtaining a first motion vector MV1 between the motion-compensated-image and one reference image R1 of a plurality of reference images at a second set time interval T2 between the motion-compensated-image and said one reference image R1;

(b) calculating a second motion vector MV2 between the motion-compensated image and another reference image R2 of said plurality of reference images at a first set time interval T1 between the motion-compensated image and said another reference image R2, said second motion vector MV2 being parallel to said first motion vector MV1 and having a magnitude satisfying the relation $MV2=MV1 \cdot (T1/T2)$;

(c) calculating pixel values of said one reference image R1 from pixels at positions corresponding to said first motion vector MV1 and calculating pixel values of said second reference image R2 from pixels at positions corresponding to said another motion vector MV2, wherein said reference images R1 and R2 are such that a motion vector MV3 between said reference images R1 and

16. A method of obtaining motion compensation for an input image, said method comprising the steps of:

(a) obtaining a first motion vector MV1 between the input image and one reference image R1 of a plurality of reference images at a second set time interval T2 between the input image and said one reference image R1;

(b) calculating a second motion vector MV2 between the input image and another reference image R2 of said plurality of reference images at a first set time interval T1 between the input image and said another reference image R2, said second motion vector MV2 being parallel to said first motion vector MV1 and having a magnitude satisfying the relation $MV2=MV1 \cdot (T1/T2)$;

(c) calculating pixel values of said one reference image R1 from pixels at positions corresponding to said first motion vector MV1 and calculating pixel values of said another reference image R2 from pixels at positions corresponding to said second motion vector MV2, wherein said reference images R1 and R2 are such that a motion vector MV3 between said reference images R1 and R2 has a mathematical relationship with said first and second motion vectors MV1 and MV2 in which said motion vector MV3 is parallel to and different in value from each of said first and second motion vectors MV1 and MV2; and

(d) calculating said motion compensation of said input image from said pixel values calculated in step (c).

17. A method of obtaining motion compensation for an input image, said method comprising the steps of:

(a) obtaining a first motion vector MV1 between the input image and one reference image R1 of a plurality of reference images at a second set time interval T2 between the input image and said one reference image R1;

(b) calculating a second motion vector MV2 between the input image and another reference image R2 of said plurality of reference images at a first set time interval T1 between the input image and said another reference image R2, said second motion vector MV2 being parallel to said first motion vector MV1 and having a magnitude satisfying the relation $MV2 = MV1 \cdot (T1/T2)$;

(c) calculating pixel values of said one reference image R1 from pixels at positions corresponding to said first motion vector MV1 and calculating pixel values of said another reference

image R2 from pixels at positions corresponding to said second motion vector MV2, wherein said reference images R1 and R2 are previous to said input image in a time sequence; and

(d) calculating said motion compensation of said input image from said pixel values calculated in step (c).

18. A method of obtaining motion compensation for an input image, said method comprising the steps of:

(a) obtaining a first motion vector MV1 between the input image and one reference image R1 of a plurality of reference images at a second set time interval T2 between the input image and said one reference image R1;

(b) calculating a second motion vector MV2 between the input image and another reference image R2 of said plurality of reference images at a first set time interval T1 between the input image and said another reference image R2, said second motion vector MV2 being parallel to said first motion vector MV1 and having a magnitude satisfying the relation $MV2 = MV1 \cdot (T1/T2)$;

(c) calculating first pixel values of said one reference image R1 from pixels which are neighbors of positions corresponding to said first motion vector MV1 and calculating second pixel values of said another reference image R2 from pixels which are neighbors of positions corresponding to said second motion vector MV2, wherein said reference images R1 and R2 are such that a motion vector MV3 between said reference images R1 and R2 has a mathematical relationship with said first and second motion vectors MV1 and MV2 in which said motion vector MV3 is parallel to and different in value from each of said first and second motion vectors MV1 and MV2; and

(d) calculating said motion compensation of said input image from said first and second pixel values calculated in step (c).

19. A method of obtaining motion compensation for an input image, said method comprising the steps of:

(a) obtaining a first motion vector MV1 between the input image and one reference image R1 of a plurality of reference images at a second set time interval T2 between the input image and said one reference image R1;

(b) calculating a second motion vector MV2 between the input image and another reference image R2 of said plurality of reference images at a first set

image, said apparatus comprising:

(a) means for providing a first motion vector MV1 between said motion-compensated image and a reference image part r1 of one reference image R1 having a plurality of reference image parts;

(b) means for calculating a second motion vector MV2 between said motion-compensated image and a reference image part r2 of another reference image R2 having a plurality of reference image parts, from said first motion vector MV2;

(c) means for calculating pixel values of said reference image parts r1 and r2 from peripheral pixels at positions corresponding to said first and second motion vectors MV1 and MV2, wherein said reference images R1 and R2 are such that a motion vector MV3 between said reference image parts r1 and r2 has a mathematical relationship with said first and second motion vectors MV1 and MV2 in which said motion vector MV3 is parallel to and different in value from each of said first and second motion vectors MV1 and MV2; and

(d) means for calculating motion-compensated pixel values from said pixel values of said reference image parts r1 and r2 to determine said motion-compensated image.

23. An apparatus in accordance with claim 22, wherein said reference images R1 and R2 are previous to said motion-compensated image in a time sequence.

24. An apparatus for determining motion compensation for an input image, said apparatus comprising:

(a) means for providing a first motion vector MV1 between the input image and a reference image part r1 of one reference image R1 having a plurality of reference image parts;

(b) means for calculating a second motion vector MV2 between the input image and a reference image part r2 of another reference image R2 having a plurality of reference image parts, from said first motion vector MV1;

(c) means for calculating pixel values of said reference image parts r1 and r2 from peripheral pixels at positions corresponding to said first and second motion vectors MV1 and MV2, wherein said reference images R1 and R2 are previous to said input image in a time sequence; and

(d) means for calculating motion-compensated pixel values of said input image from said pixel values of said reference image parts r1 and r2 to determine said motion compensation.

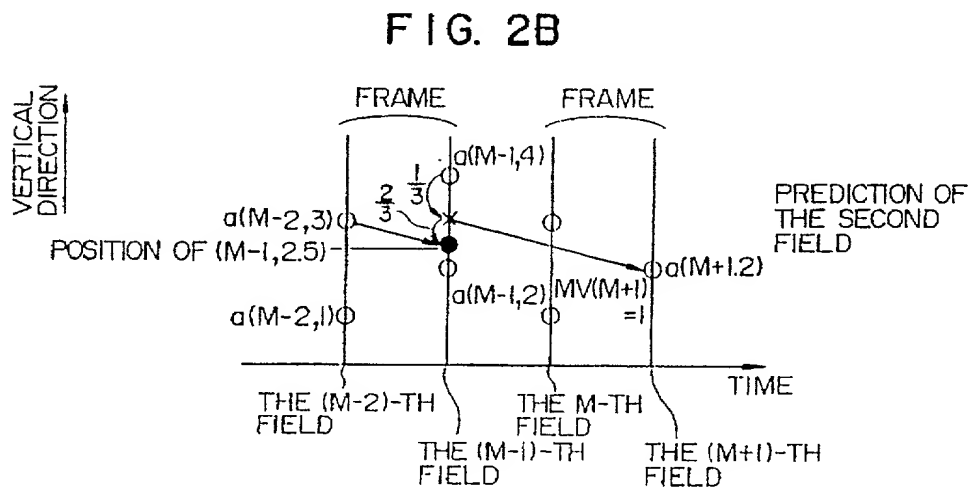
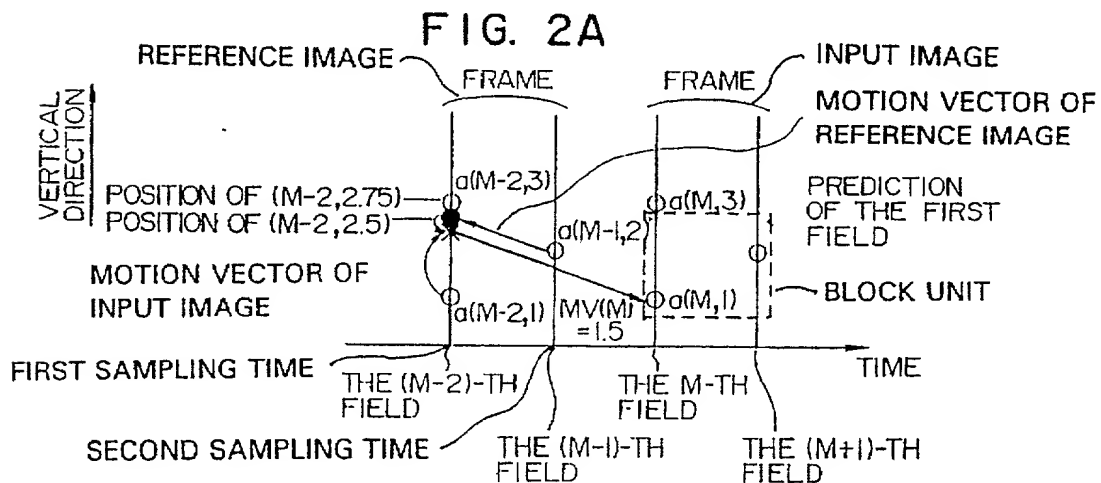
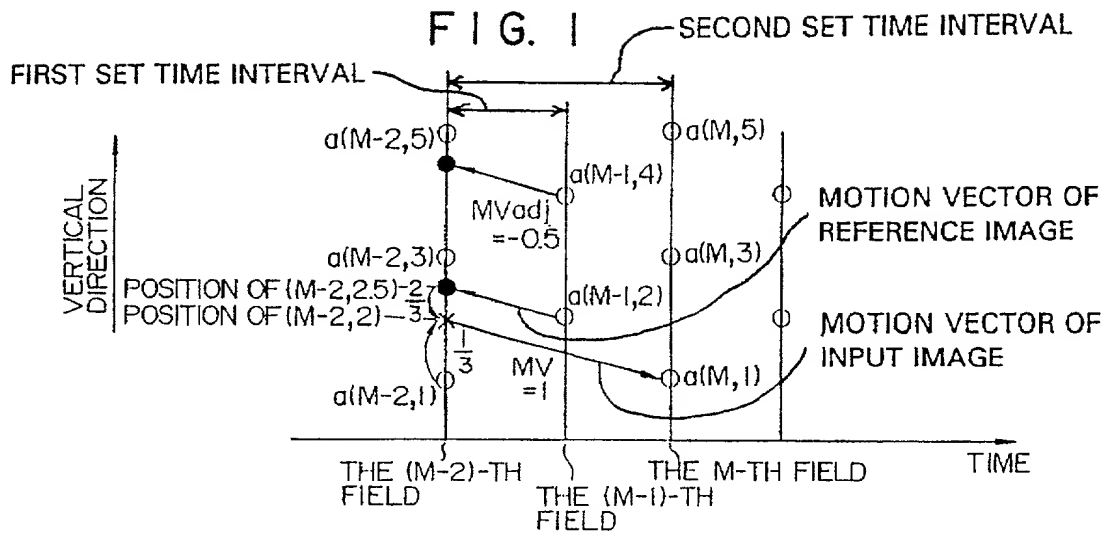
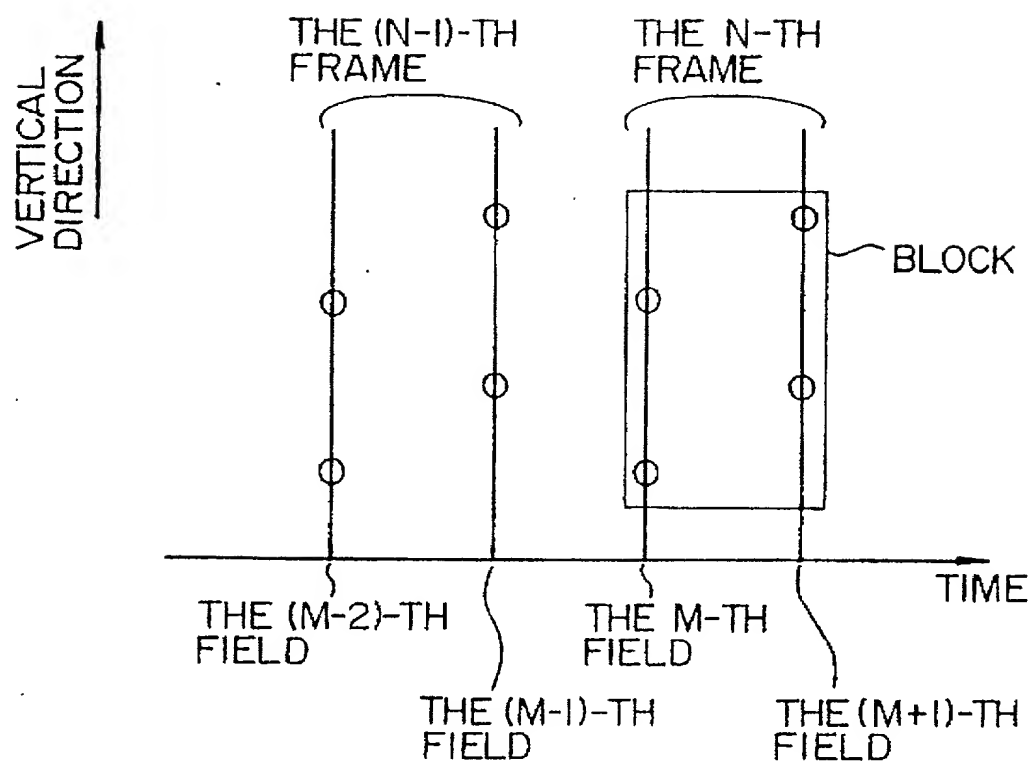


FIG. 3



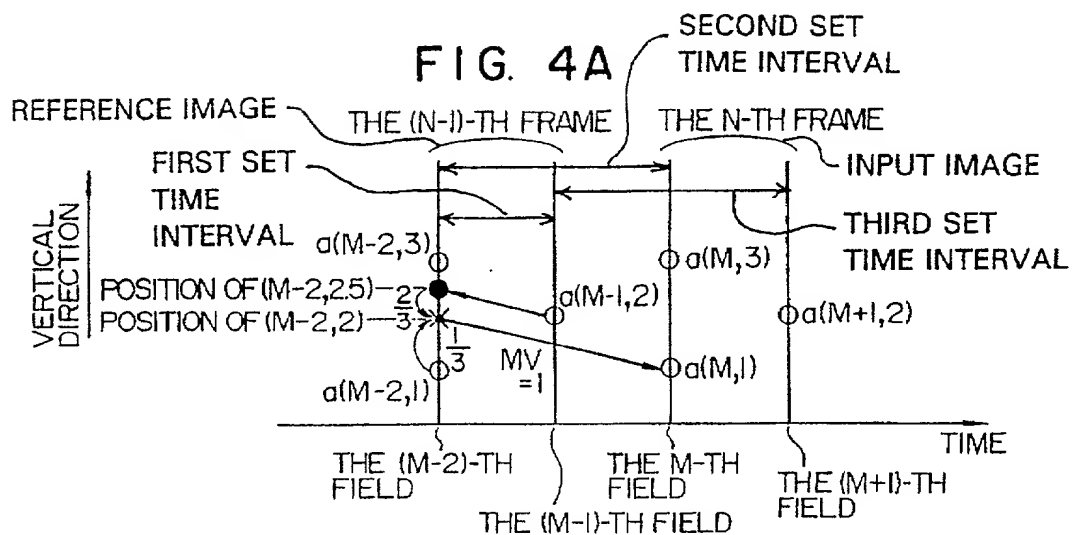


FIG. 4B

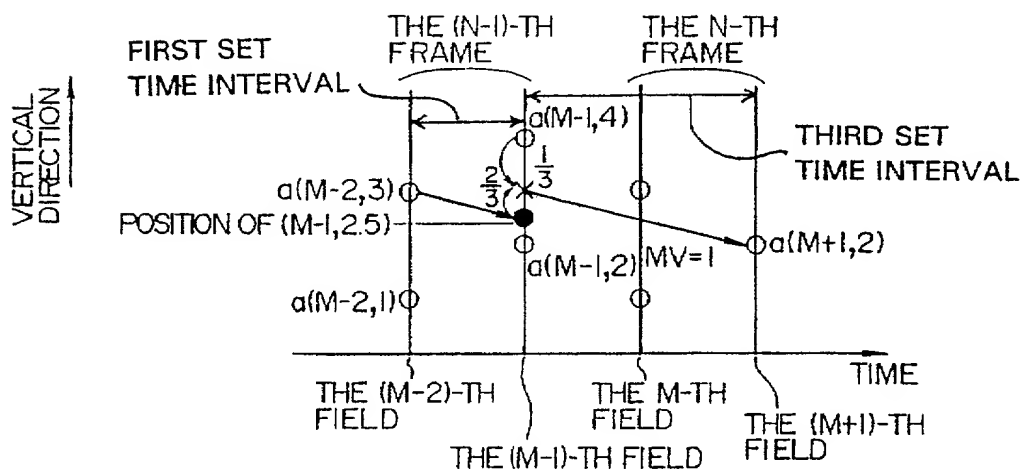


FIG. 5

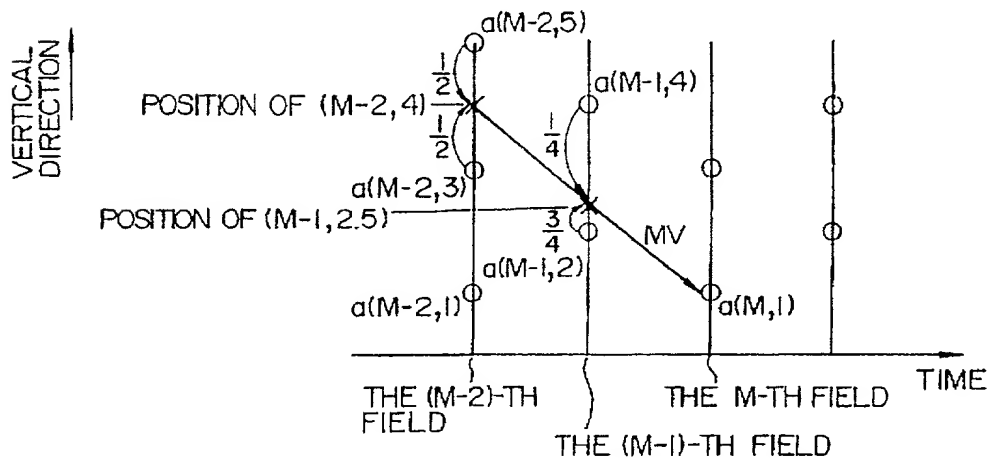


FIG. 6 PRIOR ART

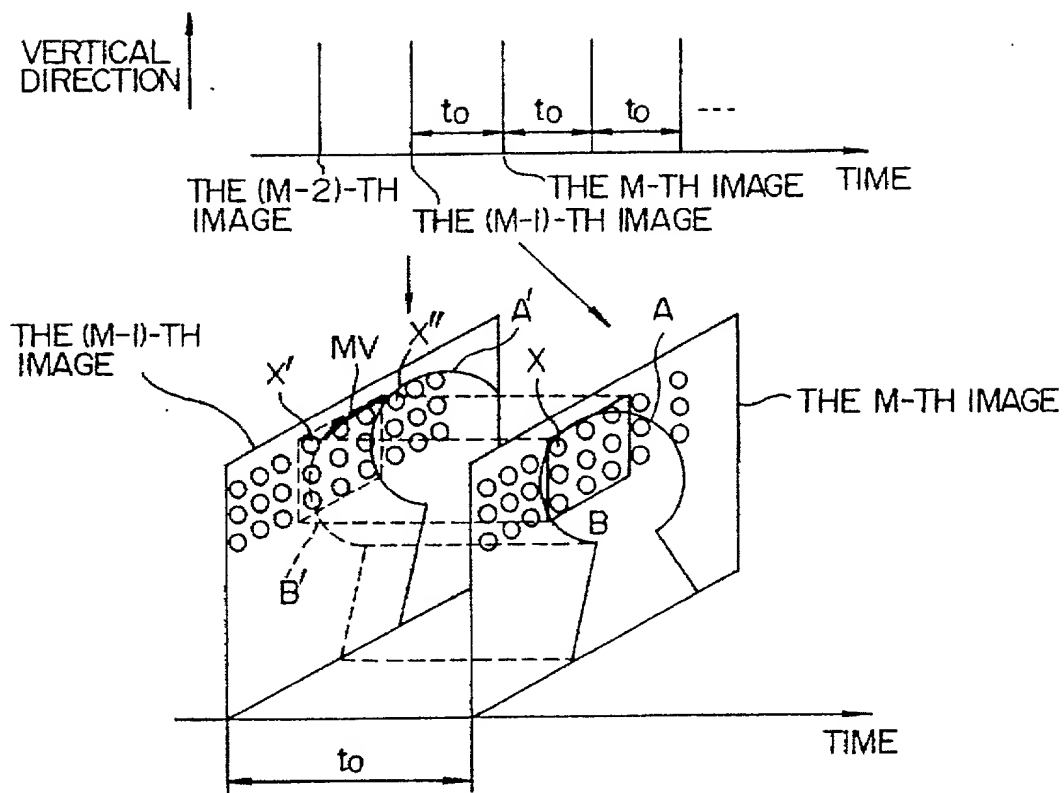


FIG. 7A PRIOR ART

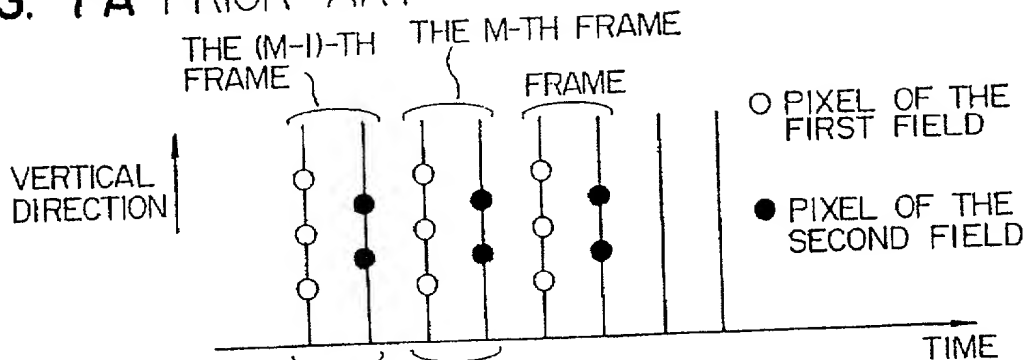


FIG. 7B

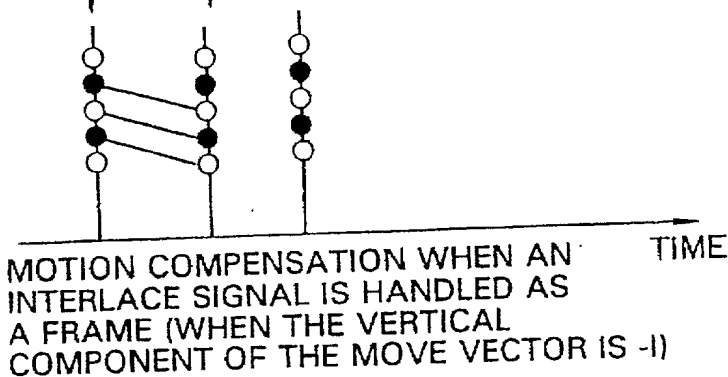
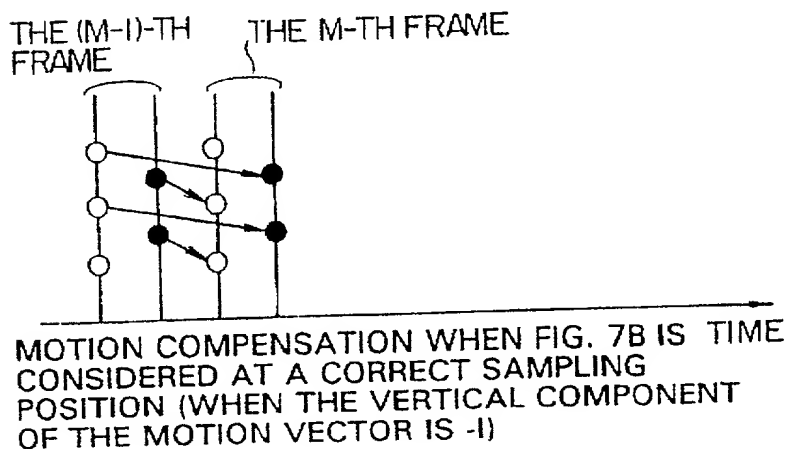
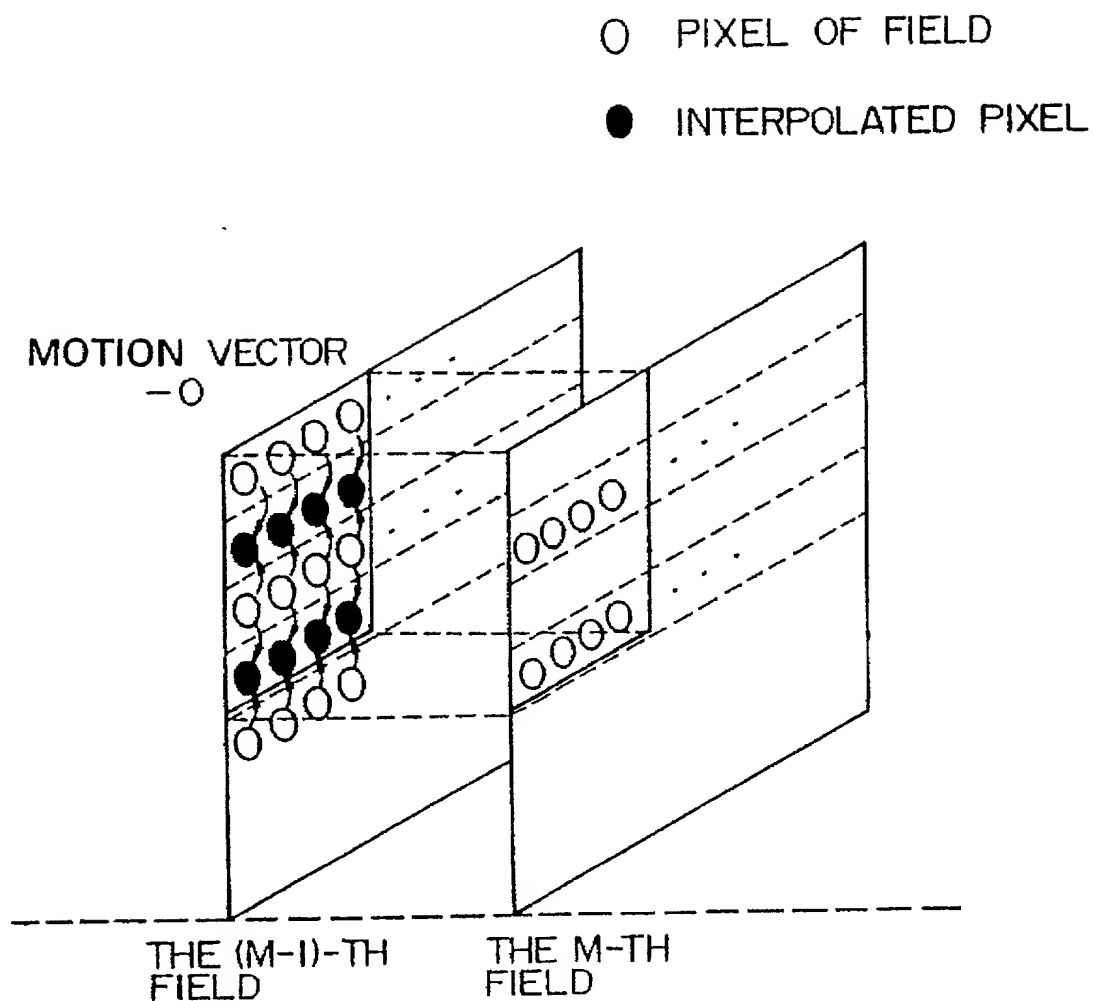


FIG. 7C



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FIG. 8 PRIOR ART



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Inventors: Takashi YUKITAKE et al.

Serial No.: Reissue Application of
U.S. Patent No. 5,745,182
(Issued: April 28, 1998)

Filed: TBD

For: METHOD FOR PREDICTING MOVE COMPENSATION

STATEMENT UNDER 37 CFR 3.73(b)

Assistant Commissioner for Patents
Washington, DC 20231

Dear Sir:

Pursuant to MPEP §1.410.01, the undersigned, a duly authorized representative of Matsushita Electric Industrial Co., Ltd., the Assignee of the entire right, title and interest in U.S. Patent No. 5,745,182, hereby establishes the Assignee's ownership interest in this patent by specifying that the evidence of such ownership interest is recorded at Reel 6322, Frame 0100 of the U.S. Patent and Trademark Office microfilm files. A copy of the recorded Assignment is attached.

For and on behalf of

MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.

(Signature)

Osamu Yamazaki
Director, Intellectual Property Center
Authorized Signing Officer

(Name)

(Date)

(Title)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Inventors: Takashi YUKITAKE et al. ASSIGNMENT BRANCH

Serial No.: Reissue Application of
U.S. Patent No. 5,745,182
(Issued: April 28, 1998)

Filed: TBD

For: METHOD FOR PREDICTING MOVE COMPENSATION

OFFER TO SURRENDER ORIGINAL PATENT

The Honorable Commissioner of
Patents and Trademarks
Washington, D.C. 20231

Sir:

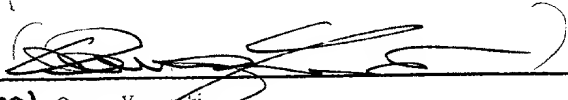
The undersigned Applicant of the above-captioned Reissue Application for the reissue of Letters Patent for METHOD FOR PREDICTING MOVE COMPENSATION, U. S. Patent No. 5,745,182, granted on April 28, 1998, of which Matsushita Electric Industrial Co., Ltd. is now sole owner by assignment and on whose behalf and with whose assent the accompanying application is made, hereby offers to surrender said Letters Patent. The original Letters Patent will be forwarded to the Patent and Trademark Office upon

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notification that the Reissue Application is in condition for allowance. A soft copy of said patent is attached hereto for reference.

For and on behalf of

MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.


(Signature) Osamu Yamazaki
Director, Intellectual Property Center
Authorized Signing Officer

(Name)

(Date)

(Title)

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Inventors: Takashi YUKITAKE et al.

Serial No.: Reissue Application of
U.S. Patent No. 5,745,182
(Issued: April 28, 1998)

Filed: TBD

For: METHOD FOR PREDICTING MOVE COMPENSATION

ASSENT OF ASSIGNEE TO REISSUE

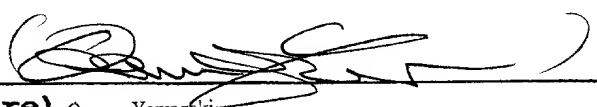
The Honorable Commissioner of
Patents and Trademarks
Washington, D.C. 20231

Sir:

The undersigned, a duly authorized representative of
Matsushita Electric Industrial Co., Ltd., the Assignee of the
entire interest in U.S. Patent No. 5,745,182, hereby assents to
the above-captioned Reissue Application of said patent.

For and on behalf of

MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.


(Signature) Osamu Yamazaki
Director, Intellectual Property Center
Authorized Signing Officer

(Name)

(Date)

(Title)